Section 2 Reasonable Expectation[1]

Issue A: Which approach to compliance demonstrations is more appropriate: "Reasonable Expectation" as proposed by the Agency, or "Reasonable Assurance" as used by the Nuclear Regulatory Commission?

1. A reasonable expectation standard is a very appropriate approach. (480) RE is the better choice for the high uncertainty areas of geologic disposal provided that the term is defined as the median value of the spectrum of probabilities estimated. Another alternative would be to use neither term and simply address the use of median values in remaining unquantified areas in the calculation of the expected annual dose. (326)

2. No other engineering project has had to meet such difficult long-term total system performance standards or such challenging "burden-of-proof"as the NRC license review process is likely to require. DOE has conducted studies and analyses of future dose levels which provide a basis for NRC to apply whatever licensing criteria are appropriate to ensuring a safe repository. (256)

3. The level of confidence adopted in the final standards must take into account the inherent uncertainties in assessing compliance for a long-term repository. DOE agrees with EPA that the appropriate level of confidence needed for compliance is less than absolute proof because absolute proof is impossible to obtain due to the uncertainty of projecting long-term performance. Whether the standard is reasonable expectation or reasonable assurance, it should reflect inherent uncertainties. (655)

4. NRC's reasonable assurance is more tested in traditional licensing experience (judicially approved since 1961) and understood by all parties to a licensing proceeding, whereas reasonable expectation is a "new", "unfamiliar" term of "dubious legal authority", and may be less conservative in that it may require a lesser level of "proof" (as EPA states it is "less stringent") and would therefore have no place in these or any other standards. NRC has congressional authority to use the reasonable assurance standard and it is well understood and judicially approved. (309) Reasonable assurance is presently being used (a "tried and true" approach) whereas reasonable expectation may be subject to debate. (348) Introduction of a new untried standard of judgement for a repository... is not necessary or appropriate...it may imply that the determination requires less rigorous "proof" than that associated with the NRC's "reasonable

[1] All acronyms are defined in Appendix B.

assurance" approach, which has a long history of implementation.(375)

5. Reasonable expectation introduces an untried and untested standard of judgement which is based on expected outcomes rather than assurances that the repository will perform to the regulatory standard. Expectation implies that some degree of uncertainty is inherent...any standard which uses expectations must be capable of quantifying uncertainty into a range of expected outcomes similar to a confidence interval. The current individual protection standard does not do that. Based upon Section 197.14(b) the reasonable expectation standard is less stringent than the reasonable assurance concept that NRC uses to license nuclear power plants... to suggest a less stringent standard for a facility which has a greater degree of uncertainty in terms of construction and operation (performance) appears to fly in the face of common sense. (501)

6. It is NRC's responsibility to judge the adequacy of compliance arguments by DOE and NRC objects to EPA's establishing "minimum requirements for implementation" and intruding into implementation. Reasonable expectation is a new term, whereas NRC has used reasonable assurance in a number of licensing activities and it is derived from NRC's AEA responsibility and approved by the Supreme Court. Reasonable assurance allows necessary flexibility to judge quantitative data with large uncertainties and has been incorporated into 10 CFR Part 63. NRC believes that EPA has no authority for implementation and licensing decisions which are the sole responsibility of the NRC. (600)

7. The EPA wrongly asserts that use of "reasonable assurance" as a basis for judging compliance would force the NRC to focus on extreme values (i.e., "tails of distributions") for representing the performance of a Yucca Mountain repository. . . The NRC has made it clear in its policy statement on probabilistic risk assessment, its proposed implementing regulation for Yucca Mountain, and its draft technical position on performance assessment for low-level waste disposal, that it does <u>not</u> focus on extreme values but rather is evaluating expected doses. The EPA should remove language that incorrectly portrays the NRC's use of reasonable assurance. (603)

<u>Response to Issue A:</u>

In the proposal, EPA described its preferred approach to implementation relative to the expectations for "proof" of repository performance considered possible for deep geologic disposal. We provided descriptions of our "reasonable expectation" approach to provide a necessary context for understanding the intent of the standard so that the actual implementation through the NRC licensing process could be developed with our intention clearly in mind. In licensing the disposal facility, NRC may choose to adopt another approach. The term "reasonable expectation" conveys EPA's position that unequivocal numerical proof of compliance is neither necessary nor likely to be obtainable in the context of long-term deep geologic disposal of radioactive wastes. EPA believes that for very long-term projections, involving the interaction of natural systems with the engineered system and the uncertainties associated with the long time periods involved, reasonable expectation is the appropriate standard of proof to be met during the licensing process. Discussion of the broad concept of reasonable expectation is given here and in

the preamble to the standards.

The NRC has used a similar test, "reasonable assurance," for many years in its regulations. The NRC, as a matter of implementation discretion, may elect to impose a "reasonable assurance" approach in its licensing decision - rather than reasonable expectation. EPA believes, however, that reasonable expectation is appropriate to assess projections of repository performance and the regulatory decisions that make use of these assessments, and we prefer it over reasonable assurance, for the reasons described below. The standard, as established by today's rule, however, does not prevent NRC from applying the reasonable assurance approach, and we expect that doing so would also include the principles of reasonable expectation described in the standard.

Comments on the application of EPA's "reasonable expectation" approach in the standard were both for and against the concept and its application to the Yucca Mountain effort. Supporters commented that the approach is reasonable in light of the inherent uncertainties in making projections of geologic conditions and estimates of repository performance over long time frames (comments 480, 655, 326). Comments opposed to the reasonable expectation concept stated repeatedly that the "reasonable assurance" approach, which is transferred from nuclear power reactor licensing experience, is more well-established and tested within a regulatory framework. These comments referred to the reasonable expectation concept in terms such as "new", "unfamiliar", and "of dubious legal authority", essentially claiming that the concept is something new being introduced into the repository effort, and an approach that in some ways would encourage less defensible or rigorous science to be used in characterizing the repository system or projecting its performance (comments 309, 348, 375). Some comments also expressed concern that the reasonable expectation approach required a lesser level of "proof" than the reasonable assurance approach and, therefore, is not appropriate for the repository situation where uncertainties can be significant (501), and that NRC does not focus on extreme values in applying the reasonable assurance approach (comments 600, 603). Two consistent themes in the comments that favor the use of reasonable assurance over reasonable expectation are that the reasonable expectation approach is untried in the licensing process and that it in some way encourages a less rigorous application of science to the repository effort.

With respect to the legal authority and use of the reasonable expectation concept in the regulatory process (comments 309, 348, 375), EPA believes that the reasonable expectation concept is well established in both the regulatory language in standards, as well as in actual application to deep geologic disposal of radioactive wastes, and has been judicially tested. We developed the "reasonable expectation" approach in the context of developing 40 CFR part 191, the generic standard for any geologic repository, and the concept has been applied successfully in the EPA certification of the WIPP, a deep geologic repository for TRU radioactive wastes [EPA 520/1-85-024-1, Response to Comments for the Final Rule (40 CFR part 191); Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes, 52 *FR* 38066, 38071 (Sept. 19, 1985); EPA 402-R-96-002, BID for 40 CFR part 194, Docket A-95-12, Item V-A-23]. The WIPP repository is, to date, the only deep geologic repository for radioactive wastes in the United States that has been approved for operation

through a regulatory approval process. In fact, the use of reasonable expectation for the application to geologic disposal has been upheld in court [Natural Resources Defense Council, vs. U.S. E.P.A., 824 F.2d 1258, 1293 (1st Cir. 1987)]. Therefore, we believe that the reasonable expectation concept is neither "new" nor "untried", nor of "dubious legal authority", in the geologic repository regulatory experience. The question of dealing with the uncertainties of projecting repository performance over time frames in the thousands to tens of thousands of years is a concern for any deep geologic repository and not a concern that can be neglected for any specific repository setting. Uncertainties in predicting site characteristics over long time periods and consequent implications for performance projections are very real for the Yucca Mountain site (Chapter 7 of the BID) and should be a fundamental consideration in decision making.

In contrast, the reasonable assurance concept was developed and applied many times in the context of reactor licensing - not in the context of deep geologic disposal efforts - and has not been used in a regulatory review and approval process for a deep geologic repository. The judicial decisions cited in one comment (comment 309) refer to the use of reasonable assurance in the context of reactor licensing, not in the context of deep geologic disposal. EPA acknowledges NRC's statements that it will apply reasonable assurance appropriately at Yucca Mountain; however, the fact remains that, while the reasonable assurance concept has an established record of successful application and judicial approval in reactor licensing, it is in fact largely untried in the arena of geologic disposal. For these reasons, we disagree with comments that contend that the reasonable expectation concept is new, untried, or of dubious legal authority (comments 309, 348, 375) in the area of deep geologic disposal. We believe the reasonable assurance approach is the more untried approach in application to geologic disposal.

NRC points out in its comment (603) about the reasonable expectation concept that its reactor-based reasonable assurance approach is being re-examined to adapt the approach to the unique aspects of repository performance, noting particularly the preference in its technical position statements for probabilistic risk assessment techniques in projecting performance. EPA has reviewed these NRC documents and agrees that the assessment approaches are useful for assessing expected repository performance and welcomes their use. Except in the case of the IPS, for which we require performance assessment that incorporates probabilistic considerations, we have made no statements mandating the use of probabilistic or deterministic methods in making performance projections, since we believe both mathematical approaches have a place in the effort to establish technical consensus on repository performance. Nor have we made any requirements for the relative weighting of analyses produced by these approaches because we feel that question is firmly in the realm of implementation that should be handled by NRC in the context of the actual licensing process. Our statements on reasonable expectation are focused on broad concepts to be applied in making performance projections, as described in more detail below, rather than the specifics of particular calculation methods that are strictly implementation decisions. While NRC is making an effort to adapt the reactor based approach of reasonable assurance to deep geologic disposal, the application is still in fact new and untried in the regulatory arena for this application.

There was some comment that suggests that EPA's approach would allow the use of less rigorous

science for the assessment of repository performance in licensing (comments 375, 309, 501). This perception may have arisen from our choice of wording in the proposal where we stated that NRC may elect to use a more "stringent" approach. Such an interpretation was not our intent. The full text of our statement in the proposal is that NRC may impose requirements that are "more stringent" than the "minimum requirements for implementation" that our rule establishes; in addition, we clearly state that reasonable expectation "is less stringent than the reasonable assurance concept that NRC uses *to license nuclear power plants*" [proposed § 197.14(b), emphasis added]. However, we will clarify our meaning here and in the final rule and preamble. Performance projections for deep geologic disposal require the extrapolation of parameter values (site characteristics related to performance) and performance calculations (projections of radionuclide releases and transport from the repository) over unprecedented time frames that make these projections fundamentally not confirmable, in contrast to the situation of reactor licensing where projections of performance are only made for a period of decades and confirmation of these projections is possible through continuing observation. In this sense, a reasonable expectation approach to repository licensing would be necessarily "less stringent" (predictions not subject to confirmation) than an approach to reactor licensing (where predictions are possible to confirm with later observation). In fact, we expect that an appropriate application of reasonable assurance to repository licensing would also be "less stringent" than it is for reactor licensing. We encourage NRC's efforts to address the significant differences between repositories and reactors in its Yucca Mountain licensing process, as it indicates it will. We, therefore, must disagree (as further explained below) with these comments that reasonable expectation requires less rigorous proof than NRC's reasonable assurance approach.

EPA does not believe that the reasonable expectation approach either encourages or permits the use of less than scientifically rigorous science in developing assessments of repository performance for use in regulatory decision-making. As stated in the preamble to the proposed rule, the reasonable expectation approach takes into account the inherent uncertainties involved in projecting repository performance. It requires that the uncertainties in site characteristics over long time frames and the long-term projections of expected performance for the repository are fully understood before regulatory decisions are made. For example, the use of bounding assessments is a common tool for performance projections when significant uncertainties exist in data or in understanding precisely how measurements of system performance relate to individual system components. Without an adequate understanding of the waste isolation and containment system, attempts at "bounding" assessments may not be bounding at all if the uncertainties in the system are not adequately understood. Under the reasonable expectation approach, a cautious approach to the use of bounding analyses would be encouraged and efforts would be directed toward understanding the interactions between relevant processes and events before bounding assumptions could be made about the larger scale repository system. As other examples, parameters important to performance would not be omitted from performance assessments, or assumed to be at their most unfavorable values, simply because their actual distribution of values is not easily quantified with high accuracy. Elicited values for relevant data should not be substituted for actual field and laboratory studies when they can be reasonably performed, simply to conserve resources or satisfy scheduling demands at the expense of gathering information that would allow a more credible understanding of the uncertainties in the long-term performance of

the repository.

Some comment expressed the opinion that EPA's use of the reasonable expectation approach intrudes inappropriately into the area of implementation, which is the province of NRC (comments 256, 600). We do not believe that is the case because NRC is not required by this rule to implement the reasonable expectation approach in making its licensing determination. The NRC, as a matter of implementation discretion, may elect not to use the reasonable expectation approach in the licensing determination. We have included the concept of reasonable expectation in the Yucca Mountain standard to provide a necessary context for understanding the standard and as context for the implementation of the licensing process NRC will perform. Because we are establishing a numerical standard for compliance, we believe that it is an appropriate exercise of our authority to discuss the context that we believe is appropriate to understand the intent of that numerical standard. The reasonable expectation concept is recommended in the Yucca Mountain standard because we believe that unequivocal numerical proof of compliance is neither necessary nor likely to be obtainable for deep geologic disposal over the time frames involved. Projecting repository performance involves the extrapolation of physical conditions and the interaction of natural processes with the wastes for unprecedented time frames in human experience, i.e., many thousands to tens of thousands of years. In this sense, the projections of the repository's long-term performance cannot be confirmed. Not only is the projected performance of the repository system not subject to confirmation, the natural conditions in and around the repository site will vary over time and these changes are also not subject to confirmation, making their use in performance assessments equally problematical over the long-term (see Chapter 7 of the BID). In light of these fundamental limitations on assessing the repository's long-term performance, we believe that the approach used to evaluate repository performance must take into account the fundamental limitations involved (including the basic guidance given in § 197.14), and not hold out the prospect the anticipation of a greater degree of "proof" (confirmable predictions, as in the application to reactor licensing) than in reality can be obtained. We are not requiring that the "reasonable expectation" approach must be adopted to the exclusion of any other approach, in fact our descriptions of the approach are broad in nature and intended as guiding principles for the actual development of a specific implementation approach for licensing the Yucca Mountain repository.

In contrast to the unconfirmable nature of repository projections, NRC has traditionally applied reasonable assurance to the licensing of highly engineered systems, i.e., power reactors, that operate over relatively short time spans, i.e., decades. Performance projections for these systems can be tested and verified during the license period for the facility. For example, the performance of containment vessels, piping, fuel rods and other man-made materials are estimated from laboratory testing, but the in-service performance is monitored and deficiencies can be corrected during the in-service time of the facility. For the case of reactor licensing, seismic hazard evaluations are the only area where the effects of potentially adverse natural processes are extrapolated in time, but in this case the extrapolation is only for a period of decades and the projection is confirmable over the licensing period for the facility. In contrast, for the geologic disposal situation, processes that affect performance take many hundreds to many thousands of years to manifest a measurable effect on performance. Most, if not all, aspects of projecting

performance of components of the repository/natural barrier system involve the extrapolation of conditions and performance over extremely long time periods, well beyond the time frames where active monitoring can be assured. Because of this dramatic difference between reactor licensing and geologic disposal, EPA believes that reasonable expectation is the more appropriate approach because it more explicitly recognizes the unconfirmable nature of repository performance projections. With that recognition, licensing decisions would, of necessity, have to explicitly recognize the uncertainties in making performance projections and the regulatory decisions based on them. We believe that compliance decisions should be made with a full understanding of the inherent uncertainties and limitations involved in projecting repository performance over long time frames, and not with an expectation that these uncertainties are lessened by applying an approach that derives from a very different situation, (i.e., the reactor licensing experience, where performance projections are much more subject to verification over the facility's operation period). In taking this position, we disagree with the comment that contends it "flies in the face of common sense" (comment 501) to apply a "less definitive" standard to a repository, which "has a greater degree of uncertainty in terms of construction and operation" than a nuclear power plant. Recognizing that a geologic repository has an inherently higher level of uncertainty in performance projections than a reactor, we believe the approach to evaluating performance should, of necessity, take these uncertainties explicitly into consideration in reaching regulatory decisions. Again, while NRC, as a matter of implementation discretion, may elect not to use the reasonable expectation approach in considering the licensing case put forth by DOE, we believe that applying the principles of reasonable expectation is a more appropriate and realistic way to assess projections of repository performance and the regulatory decisions that make use of these projections and that whatever approach NRC adopts for implementation would at least incorporate the principles described for our reasonable expectation approach. The NRC's comments (600, 603) on our proposal indicate that it recognizes the importance of avoiding "unnecessary conservatism" in probabilistic analyses, which is consistent with our principles for reasonable expectation, if not defined in detail. As explained in the text below, excess conservatism can arise from two sources, unrealistic assumptions in framing performance scenarios, and the selection of parameter values for calculations. Probabilistic approaches can effectively put parameter value selection into a proper context by providing a means to weight individual performance calculations. The more basic framing of the performance scenarios is not as easily or directly addressed by probabilistic techniques (see discussion of the example below).

Moreover, because EPA is not requiring that NRC use reasonable expectation in its licensing determination, but, rather, is recommending that reasonable expectation be the minimum level of proof used, EPA does not intrude inappropriately into NRC's implementation responsibilities for decision making. The primary task for the regulatory authority is to examine the performance case put forward by DOE to determine "how much is enough" in terms of the information and analyses presented, (i.e., how will the regulatory authority determine when the performance case has been demonstrated with an acceptable level of confidence?). We have proposed no specific measures in our standard for that judgement, as one comment suggested we must to justify our approach (comment 501). We have not specified any confidence measures for such judgements or numerical analyses, nor prescribed analytical methods that must be used for performance assessments, quality assurance measures that must be applied, statistical measures that define the

number or complexity of analyses that should be performed, nor have we proposed any assurance measures in addition to the numerical limits in the standard. We have specified only that the mean of the dose assessments must meet the exposure limit, without specifying any statistical measures for the level of confidence necessary for compliance. We believe that measure is a minimal level for compliance determination consistent with the application of the individual protection requirement we applied for the WIPP certification [40 CFR 194.55(f)]. For the WIPP certification, EPA is also the implementing agency and in 40 CFR Part 194 we also included implementation requirements, including statistical confidence measures for the assessments and analytical approaches [Sections 194.55(b), (d), (f)] along with quality assurance requirements (Section 194.22), other assurance requirements (Section 194.41), requirements for modeling techniques and assumptions (Sections 194.23 and 25), use of peer review and expert judgement (Sections 194.26 and 27). We have not incorporated a similar level of detail in the Yucca Mountain standard because we believe we must specify only what is necessary to provide the context for implementation. We believe that our discussion of the reasonable expectation approach provides a necessary context for understanding the intent of the standard and for its implementation. We have provided guidance statements in the standard (Section 197.14) relative to the approach we believe appropriately addresses the inherent uncertainties in projecting the performance of deep geologic repositories. The implementing agency is responsible for developing and executing the implementation process and is free to adopt an approach it believes is appropriate to the site-specific situation at Yucca Mountain, but we believe that whatever approach is implemented should be consistent with the aspects of reasonable expectation we have described in the standard and amplified upon in these responses to comments.

Along these lines, one comment (comment 326) urged that EPA specify that the mean value of the spectrum of dose assessments weighted according to their probabilities be defined as the compliance measure. We basically agree with the thrust of the comment, that the repository dose assessments should consider the relative probabilities of expected processes and events and that biasing the performance projections by an overemphasis on low probability but high dose consequence scenarios should be avoided. We note that dose assessments for the Yucca Mountain site performed by DOE have adopted a probabilistic approach (DOE/VA, DOE/RW-0508, vol. 3, and Draft EIS, DOE/EIS-0250D, Docket A-95-12, Items V-A-5 and V-A-4). We also note that the NRC draft standard incorporates requirements that imply a probabilistic approach to the dose assessments [10 CFR 63.114(b) and (d)], and that NRC in its comment on the proposed standard noted its efforts to incorporate probabilistic risk assessment approaches into its licensing approach. We believe that the probabilistic approach is well established in the geologic disposal field and that it is not necessary for us to require a probabilistic approach to dose assessments in our standard. We believe the probabilistic approach will be implemented by DOE and NRC. We also implicitly incorporated a probabilistic approach in § 197.12 of our proposal, where we stated that performance assessments must consider the probabilities of occurrence of processes and events that might affect the Yucca Mountain disposal system. In keeping with our intention to avoid imposing unnecessary requirements that might constrain implementation flexibility, we were concerned that specifying in our standard that probabilistic approaches be used, may imply that deterministic assessments cannot play a role in the compliance case. We believe the relative role of deterministic versus probabilistic assessments in building and

evaluating the compliance case should be left to the judgement of the applicant and regulatory approval authority. However, we have adopted wording along the lines suggested by the commenter to be more explicit as to our intent. Our final rule requires that the IPS demonstrate compliance through performance assessment. The definition of performance assessment explicitly states that dose estimates are to be weighted by the probability of their occurrence. We do not require that DOE use performance assessments to demonstrate compliance with the human intrusion and ground-water standards, which leaves DOE and NRC the flexibility to consider deterministic analyses for that purpose. However, if performance assessments are used, they would incorporate probabilistic aspects similar to those used for the IPS.

One comment suggested that the Yucca Mountain performance assessment will have to quantify judgments "in far more detail than in past NRC compliance proceedings" (comment 256). This comment appears to support the use of "reasonable expectation"; however, the comment also expresses support for NRC's positions on the standard, which call for the reasonable assurance approach. EPA agrees with the comment's assertion that the time frame for the performance projections is unprecedented in engineering efforts. We believe that our reasonable expectation approach, as described previously, responds appropriately to the understanding and treatment of the inherent uncertainties involved in these long-term assessments of repository performance, and therefore, we believe our approach is consistent with the intent of this comment.

Another comment (comment 603) stated that NRC does not focus on extreme values in repository performance assessments and that EPA's description of reasonable expectation and reasonable assurance in the preamble to the proposed rule could be potentially misleading in this respect. The NRC cited several documents in its defense. Though the statements referenced by NRC are not as detailed as we would like in outlining the level of proof demanded under reasonable assurance to make a compliance determination, we recognize that NRC's assessments of repository performance will give consideration to the full range of values for relevant performance parameters. Our phrasing in the preamble for the proposed rule was not as clear as it should have been to convey the intent of our statements. In particular, we intended to warn generally against focusing on tail-ends of parameter distributions, and our statement in the standard itself does not say that reasonable assurance typically does so or that the application of reasonable assurance to the geologic repository application will or must do so; again, we are not the implementing authority and therefore we cannot assume how reasonable assurance will be applied to the Yucca Mountain site. We will take the opportunity here to explain the intent of our statements more fully to explain how excessively conservative assumptions can result in performance projections that essentially focus on the "tails" of distributions of otherwise more realistic assessments.

There are two fundamental components to be established in setting up and analyzing repository performance scenarios. First, the scenario itself and associated assumptions must be established, and second, the distribution of expected values for the parameters involved in the performance calculations must be determined. The scenario is developed from an understanding of the natural processes, the engineered barrier design, and its interactions with the repository environment. The range of expected parameter values for the analyses is based on the results of site

characterization studies and laboratory testing. For both of these components, unrealistic and perhaps extreme choices can be made that would in effect give false expectations of repository performance, or hide important uncertainties that would in reality have important consequences on the performance projections. If extreme assumptions are made in defining the scenario, a "worst-case" scenario is developed at the outset and analyses using the expected range of site parameter values result in performance projections that are in fact extreme cases, rather than representing the full range of expected performance. Effectively, such a restrictive approach results in emphasis on what would be the extremes of the probability distributions for the dose assessments if a realistic approach were taken in defining the performance scenarios. On the other hand, if the scenario were defined more realistically and the same distribution of site parameter values used, the resultant distribution of doses would be closer to the actual expected performance and regulatory decisions could be made with confidence that the assessments represent the full range of realistic expected performance. Including multiple "worst-case" assumptions in setting up the performance scenarios, combined with selecting conservative values for site-related parameter distributions, actually corresponds to assessing very low probability scenarios which can then easily be mistaken as expected case analyses. Under the reasonable expectation approach, expected case versus conservative and worst-case assessments would be more explicitly identified and the uncertainties presented more directly so that regulatory decisions can be more easily made and defended.

As a specific example, the DOE/VA report (DOE/RW-0508) presents results of performance assessments for the repository which are in fact extreme, rather than expected, performance. In these assessments, all ground water that seeps into the waste emplacement drifts is assumed to contact the waste packages, whereas the diameter of the waste packages is in reality only one-third that of the emplacement drift. This results in an over-estimate of the water available to contact the waste packages by at least a factor of three. The range of water seepage rates is determined by the hydrologic and climate variation data for the site, but this overly conservative assumption biases all the calculations to extreme values. Overestimating the water inflow leads to earlier failure of the waste packages than would otherwise be expected, increased transport of radionuclides out of breached waste packages, and consequently higher resultant doses than would be realistically expected. While it would be impossible to quantify the exact amount of water contacting the waste package, making a worst-case assumption for the scenario at the outset generates overly conservative results. Since these assessments did not consider some other uncertainties in the performance, the dose assessments can be easily interpreted as unrealistically non-conservative - if one assumes that these additional untreated uncertainties would result in further adverse performance. Until these additional uncertainties are analyzed, it is equally possible that the excessively conservative (unrealistic) assumptions built into the basic performance scenario could easily compensate for the untreated uncertainties. By having unrealistically severe assumptions for the analyzed performance scenario, it becomes very difficult to weigh the importance of all the uncertainties and come to a defensible picture of the actual variation in the expected performance of the repository and the inherent uncertainties. To further illustrate this point, for this particular example assumptions were made about premature failures of waste packages from manufacturing defects. One premature failure was assumed during the 10,000 year period for the assessment. With the overestimate of ground water contacting the

waste packages, seventeen additional waste packages were breached by corrosion processes and released radionuclides. With more realistic assumptions about available water, fewer waste packages would be projected to fail by corrosion during the regulatory time period, and the relative importance of the premature package failures to repository releases becomes more apparent, thereby allowing this inherent uncertainty to be identified and addressed in design efforts, as well as more visibly in performance assessments.

This page intentionally left blank.